A Q-Test Based Glitch Detection Algorithm

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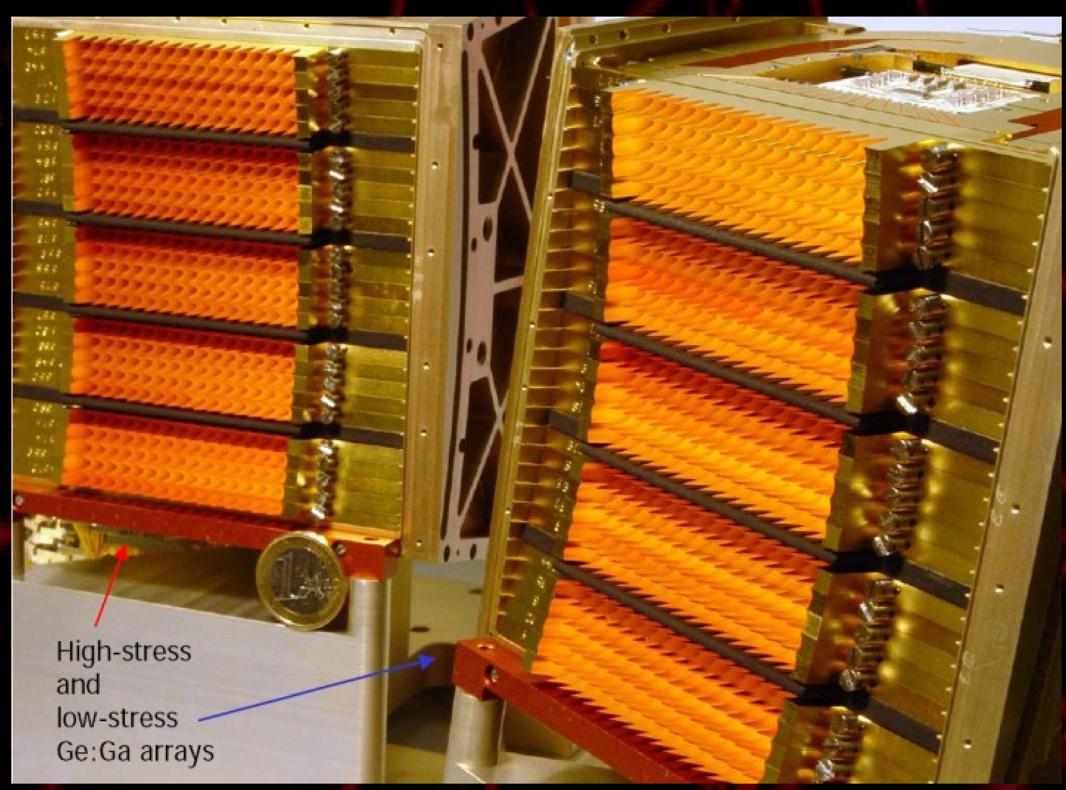
Abstract: We present a new glitch detection method, based on a series of locally applied statistical q-tests. The method was developed, and tuned, for the spectrometer of the Herschel-PACS instrument. Sample results obtained in this context are presented.



Herschel-PACS spectrometer arrays

Herschel-PACS Spectrometer

- The Herschel Space Observatory's launch is scheduled for early 2009
- The spectrometer of the PACS instrument comprises 2 photoconductor arrays of 25 x 16 Ge:Ga detectors [1]
- Each array is under very different mechanical stress
  - Blue array (57-100 microns) under low stress (LS)
  - Red array (103-210 microns) under high stress (HS)
- Ge bulk photoconductors are very sensitive to ionizing particles
- The radiation environment predicted for L2 is similar to what was observed during the ISO mission (mostly protons), but the operating conditions will be very different (high telescope background, no regular detector curing foreseen)
- The raw signal of the spectrometer is made of integration ramps of ¼ s, sampled at 256Hz. In flight, the on-board software will reduce the sampling to 32 or 16 Hz, possibly hampering glitch-detection on ramp level.

Radiation effects on Ge:Ga detectors

- Long term responsivity increase compared to lab.(τ = hours)
- Particle hits produce discontinuities in the ramps (Fig 1)
- These induce instantaneous response changes (IRCs) of different nature for the low & high stress detectors (Fig 1 & 3).

Q-test

$q_i = |X_i - X_{i\_n}| / R$ where

X_i is the tested sample

X_{i_n} is the nearest neighbour (in value, not time)

R is the total range covered by all X_i

Algorithm For an integration ramp r(t), sampled at r_i, $i \in [1,N]$

. Obtain “first derivatives” $d1 = (r_{i+1} - r_i)$ and $d2 = (r_{i+2} - r_i)$

. Build d1' & d2' by excluding the $n_{highest}$ & n_{lowest} extreme values from d1 & d2

. Ramp discontinuities will affect one sample in d1, but 2 in d2 ⇒ $n_{highest}$ and n_{lowest} should be chosen twice as large for d2 than for d1

. Build contrast functions q1 & q2 == q-tests of d1' & d2'

. Thanks to the pre-exclusion of potential outliers, the distributions of q1 & q2 are identical for all ramps, containing glitche(s) or not.

. This allows to flag glitches based on a very simple thresholding of q1 & q2 combined: samples with $q1_i$>threshold, $q2_i$ & $q2_{i-1}$ > threshold/2 are flagged.

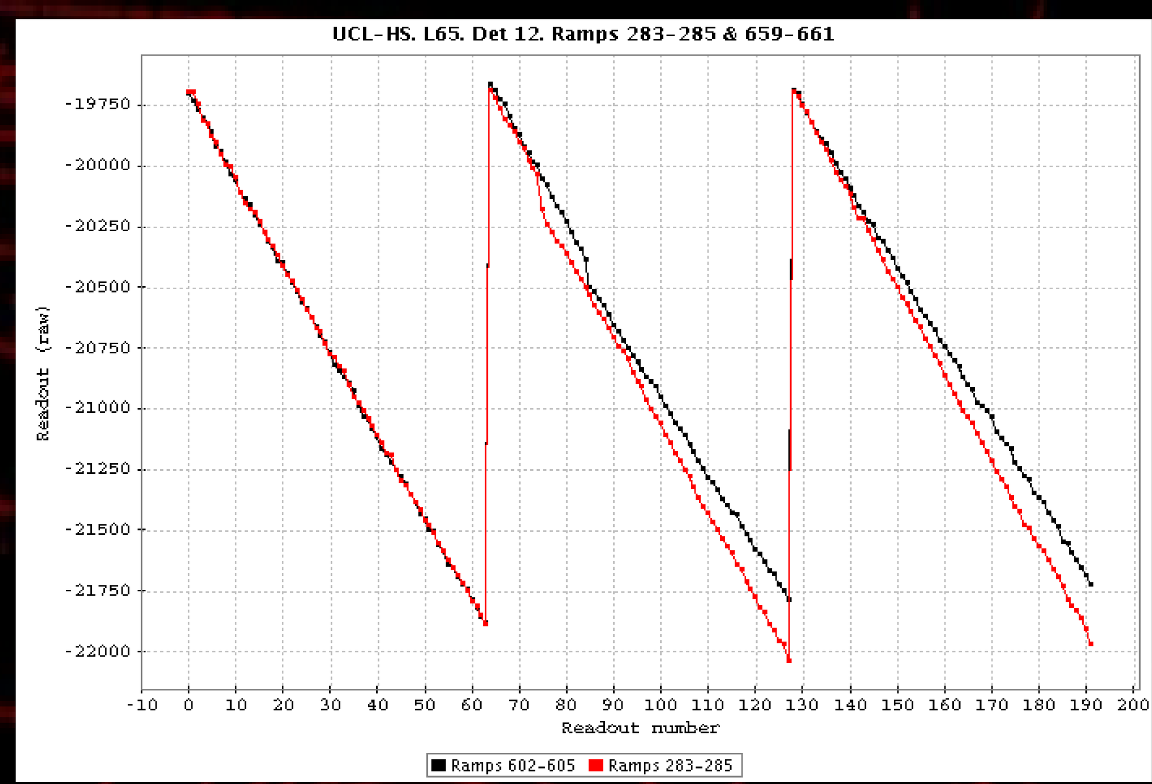


Figure 1: 2 x 3 raw integration ramps of low stress detectors from the same dataset. Both central ramps exhibit comparable glitches, though last ramps respectively display lower / higher responsivities (slope)!

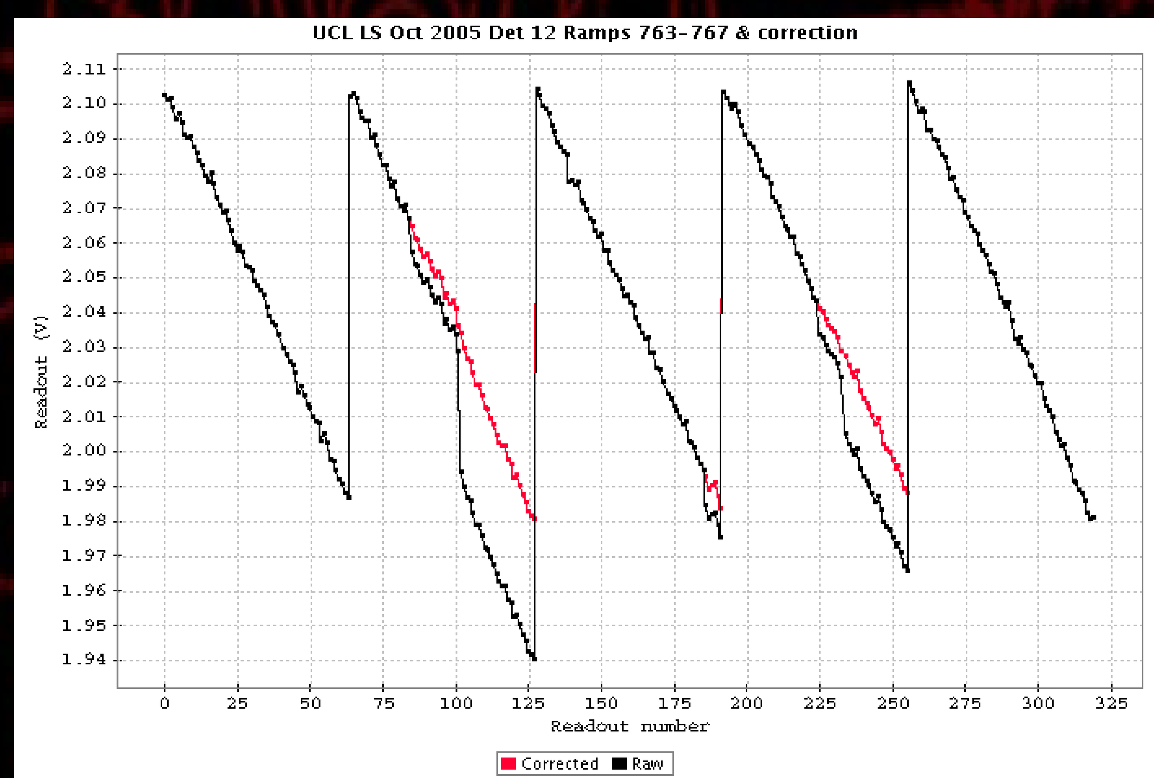


Figure 2: “q-deglitching” of a sample of raw ramps. The red curves show the corrected ramps, assuming a glitch height = $d1_i$ - Median(d1)

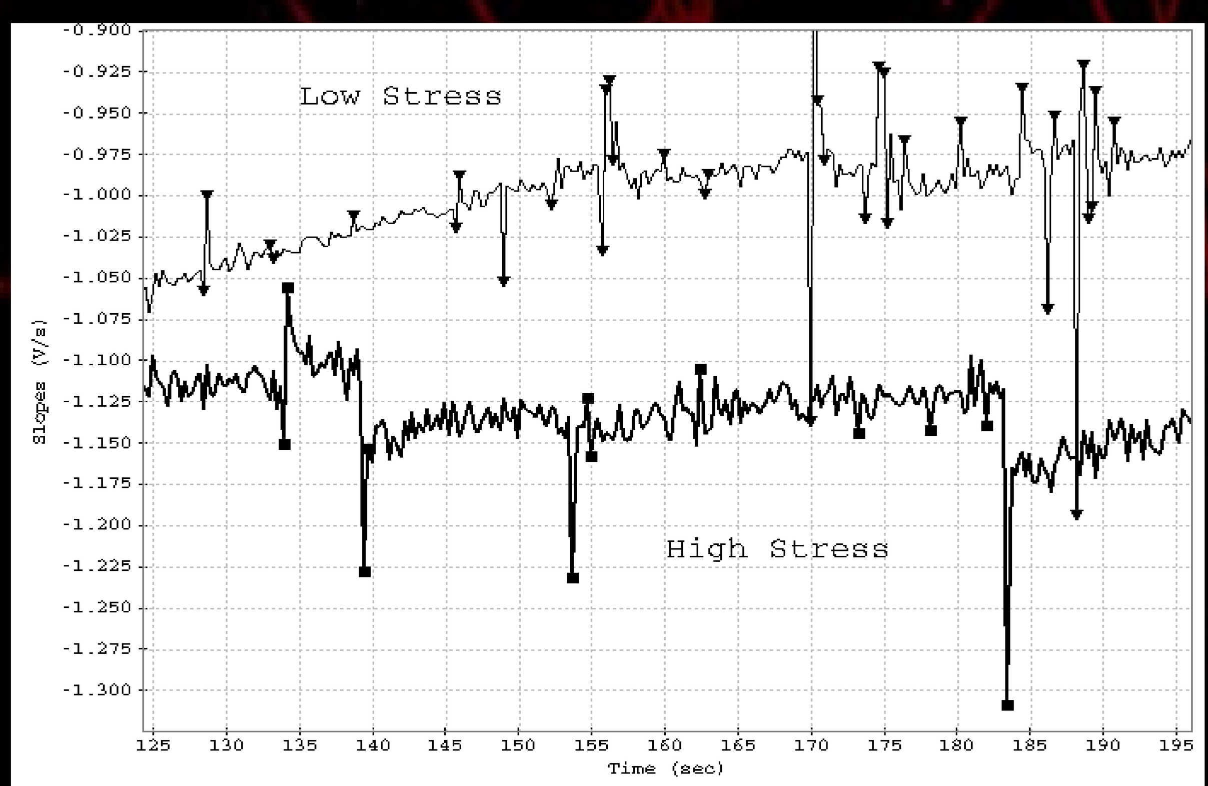


Figure 3: “q-deglitching” samples of PACS spectrometer signal obtained under proton irradiation [2]. The signal corresponds to slopes fitted to the raw ramps (Fig 1). The instantaneous glitch effect on detector responsivity is very different for LS and HS detectors, with short tails for LS and large time constants for HS

Algorithm For the detector signal (ramp slope vs time, Fig 3)

- Here, the signal contains large excursions of responsivity on short, medium and long timescales, which implies a local treatment.
- Various types of glitch effects + tails must be identified.

The method is unchanged, except for the following:

. q-test is established over a sliding box of width w

. contrast functions $q1_i$ & $q2_i$ become Max(q_i) over the w q-test scores involving sample i

. Thresholding can be tuned to the shapes of the features to flag

Results Several deglitching methods have been compared in a double-blind approach on simulated data (raw ramp deglitching, Fig 2) [3]. The other methods were σ-clipping, ISOPHOT algorithm [4], various flavours of Slope Deviation Error [5], and a method based on modified z-tests. This exercise placed the q-deglitching on top of performance wrt detection efficiency & false detections. Comparison with multiresolution methods is underway [6].

References:
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